CHLORIDE RESISTANCE PENETRATION OF RUBBERIZED-ULTRA-HIGH PERFORMANCE CONCRETE (UHPC)

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor Degree in Civil Engineering.

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Pelupusan sisa pepejal dari produk sampingan sisa adalah salah satu isu alam sekitar yang utama pada masa kini seperti pelupusan tayar. Penggunaan tayar kitar semula sebagai pengganti agregat dalam konkrit biasa dan konkrit kekuatan tinggi telah diterokai. Kini, UHPC telah menjadi terkenal kerana kekuatan mampatan tinggi yang boleh mencapai lebih daripada 100 MPa. UHPC dihasilkan dengan menggunakan nisbah simen air rendah dan menggantikan simen Portland biasa (OPC) dengan 10% silika asap yang bertambah baik dengan ketara kebolehkerjaan, kekuatan dan ketahanannya. Dalam kajian ini, satu idea untuk menggantikan jumlah agregat dengan sisa serbuk getah (WCT) dalam campuran UHPC telah dikaji. WCT diganti secara berterusan pada 5% daripada jumlah berat agregat. Zarah WCT tertakluk kepada proses pra-rawatan dengan merendam zarah WCT dalam larutan NaOH selama 20, 40 dan 60 minit. Dua (2) jenis ujian iaitu ujian ketahanan dan penembusan klorida telah dijalankan. Untuk ujian ketahanan, sampel UHPC telah direndam dalam larutan 3% NaCl selama 7, 14 dan 28 hari dan spesimen yang terdedah telah diuji dari segi kekuatan dan penurunan jisimnya. Kedalaman penembusan klorida UHPC yang terdedah juga dinilai. Keputusan menunjukkan bahawa kekuatan mampatan untuk keseluruhan getah-UHPC jauh lebih rendah dalam kekuatan berbanding dengan UHPC biasa. Kedalaman penembusan klorida untuk getah-UHPC adalah nilai yang lebih tinggi berbanding dengan UHPC biasa. Dalam getah-UHPC, UHPC-20 mempunyai nilai yang lebih tinggi untuk kedalaman penembusan klorida daripada UHPC-40 dan UHPC-60. Hasilnya menunjukkan bahawa UHPC-60 meningkatkan penembusan tahan klorida daripada UHPC-20 dan UHPC-40.

ABSTRACT

Solid waste disposal from waste by-products are one of the major environmental issue nowadays such as tires disposal. The utilization of recycled tyre as aggregate replacement in normal concrete and high strength concrete has been explored. Nowadays, UHPC has become famous due to high compressive strength that can achieved more than 100 MPa. UHPC was produced by using low water cement ratio and replacing the ordinary Portland cement (OPC) with 10% silica fume improved significantly its workability, strength and durability. In this study, an idea to replace the amount of aggregate with waste crumb tyre (WCT) in UHPC mixture was investigated. The WCT was replaced constantly at 5% from the total weight of aggregate. The WCT particle was subjected to pre-treatment process by immersing the WCT particles in NaOH solution for 20, 40 and 60 minutes. Two (2) type of testings namely durability test and chloride penetration were conducted. For durability test, the UHPC samples were immersed in 3% NaCl solution for 7, 14 and 28 days and the exposed specimens were tested in terms of its strength and weight loss. The chloride penetration depth of exposed UHPC was also evaluated. The results showed that the compressive strength for entire rubberized-UHPC significantly lowest in strength as compared to plain UHPC. The chloride penetration depth for rubberized-UHPC was higher value as compared to plain UHPC. In the rubberized-UHPC, UHPC-20 has higher value for chloride penetration depth than UHPC-40 and UHPC-60. The results revealed that UHPC-60 enhanced the chloride resistant penetration than UHPC-20 and UHPC-40.

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LIST OF SYMBOLS

%	Percentage
m^3	Meter cubic
mm	Milimeter
MPa	MegaPascal

LIST OF ABBREVIATIONS

$AgNO_3$	Silver Nitrate
HPC	High Performace Concrete
NaCl	Sodium Chloride
NaOH	Sodium Hydroxide
UHPC	Ultra-High performance Concrete
WCT	Waste Crumb Tyre

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Ultra High Performance Concrete or known as UHPC is a cementitious composite materials composed of an optimized gradation of granular constituents and water-to-cementitious materials ratio less than 0.25. The compressive strength and tensile strength of UHPC was greater than 150 MPa and the value tensile strength was greater than 5 MPa, respectively (Graybeal, 2011). UHPC is one of the latest advances in concrete technology and it addresses the shortcomings of many concretes today. The discontinuous pore structure in UHPC can reduces the liquid ingress and also increasing the durability of UHPC when compare to those of conventional concrete and high performance concrete (Graybeal, 2011).

As well known, UHPC was produced by using quartz as aggregate, therefore it become very expensive. To reduce the cost of production, the quartz can be replaced by using alternative material from waste products. In this study, the present of waste crumb tyre as aggregate replacement will be introduced. Nowadays, a millions of rubber tubes or rubber tires have been produced for human consumption every year. This excludes waste tyre that can only cause mosquito reproduction and also cause increased earth temperatures due to widespread burning of waste tyre. This causes a very high environmental pollution. In order to reduce pollution problem, the use of waste crumb tires (WCT) is one of the alternative to replace the aggregate in the UHPC.

However, previous researcher found that the bonding or the strength between the rubber particles with the cement matrix in concrete were weak (Ankit, 2016). To overcome the problem on bonding between the rubber particles with the cement matrix about to increase the strength of rubberized-UHPC there is the method that the past

researchers were done. Several researchers, Ankit, (2016) and Sofi, (2016) found that the process of surface treatment by using chemical solution has been suggested. The chemical solution used for the surface treatment of WCT is sodium hydroxide (NaOH). NaOH solution is a great chemical in cleaning agent to take out the dirt and cleans the surface of rubber. Thus improves the bonding between the waste crumb tyres with cement matrix of concrete.

The modification of UHPC containing WCT needs future investigation on its durability such as chloride resistance penetration. The UHPC specimens were immersed in sodium chloride (NaCl) solution to investigate the durability of rubberized-UHPC. In this present study, the tests conducted are compressive strength and chloride penetration.

1.2 Problem Statement

Traditionally, to produce the ultra-high performance concrete (UHPC), the materials that used are Portland cement, silica fume, fine sand, ground quartz, water and superplasticizer. However, the quartz is very expensive because it is natural resources and it became limited sources in Malaysia. Therefore, to reduce the cost of the UHPC, the quartz should be replaced with other waste materials. In this study the waste material used is waste crumb tyre. In Malaysia, it is estimated that of 57,391 to 8.2 million tons production of waste tires every year where, more than 50% amount of waste tires were disposed wrongly (Thiruvangodan and Sandra, 2006). Due to increases of the waste tyres, the price of the waste tyres become cheap and easy to obtained. Several researchers were used the waste tyres as aggregate replacement material in the normal concrete (Michelle, 2006; Ankit, 2016). In Malaysia, there are many of the waste tyres were dump at the landfill of Madang, Kayu, Telipok, Sabah. The expanse of this landfill was about 0.5 hectares and it can support all the waste tyre in Telipok. However, this placed was destroyed by fired and resulting air pollution due to this incident in January 2017. Therefore, this is the opportunity to researcher to make the innovation to use the WCT as aggregate replacement in concrete.

However, Ankit (2016) has been observed that the bonding between the rubber particles in cement matix was very weak. To improve the bonding between the rubber particles with the cement matrix, the surface treatment of rubber particles should be treated. NaOH solution is perfect as cleaning agent to remove the dirt and also clear the

surfaces. There are different in duration of immersion WCT into NaOH solution from the previous research. Therefore, the further investigation on the duration of immersion were be carried out. All the rubberized-UHPC specimens will be exposed into chloride to investigate the durability performance. Effect on different duration of WCT surface treatment subjected to chloride penetration was main concern in this study.

1.3 Objective of Study

i. To determine the effect of using different pre-treatment duration on surface of waste crumb tyre particles as aggregate replacement in UHPC.
ii. To determine the compressive strength of rubberized-UHPC subsequently immersed in sodium chloride (NaCl) solution.
iii. To examine the chloride penetration profiles on exposed rubberized–UHPC immersed in NaCl solution.

1.4 Scope of Study

The present study focused on the determinants of strength loss and chloride resistance penetration of rubberized-UHPC incorporated waste crumb tyre. In order to produce rubberized-UHPC the aggregate in UHPC was replaced with the waste crumb tyre (WCT). To achieve the objectives, this study was carried five (5) stages as outlined in the following sequences.

Stage 1: Pre-Treatment on Surface of Waste Crumb Tyre Particles

In order to use WCT as an aggregate replacement in UHPC production, the raw particles of WCT underwent to the pre-treatment process. Before the treatment process, the WCT particles were cleaning using acetone to remove the probable impurities on the WCT surface. Then, WCT was immersed in NaOH solution as pre-treatment. NaOH is a powerful cleansing agent removes the dirt and cleans the surface of rubber which enhances the bonding between the rubber aggregate with the other materials in concrete. There are four (4) different in duration of the immersion 0, 20, 40 and 60 minutes.

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